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Bellefonte Unit 3 and 4 COLA: Design Basis Flood Calc Review

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Presentation Purpose

Common understanding of:

- NRC's methodology for reviewing TVA's design basis flood calculations
- Relationship between NRC's review schedule and TVA's milestones as outlined in letters from TVA dated June 30 and July 10, 2008.
- Discuss process for NRC review of TVA's data packages and NRC's potential data requests.

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Review Methodology

Relevant Title 10 Section *(paraphrased)*:

§52.79(a)(iii) The FSAR shall include information on the...**hydrologic characteristics** of the site with appropriate consideration of the **most severe of the natural phenomena** that have been historically reported for the site and surrounding area with **sufficient margin** for the limited accuracy, quantity, and time in which the historical data have been accumulated.

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Review Methodology (cont.)

Relevant Title 10 Section *(paraphrased)*: Part 50, Appendix A

GDC 2 – SSCs important to safety shall be designed to withstand the effects of…hurricanes, floods… **without loss of capability to perform their safety functions**. The design bases for these SSCs shall reflect: (1) appropriate consideration of the **most severe of the natural phenomena** that have been historically reported for the site and surrounding area, and with **sufficient margin** for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) **appropriate combinations of the effects** of normal and accident conditions with the effects of the natural phenomena, and (3) the **importance of the safety functions** to be performed.

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Review Methodology (cont.)

SRP 2.4.2 Review Procedures guidance:

- In order to establish the design-basis flood water elevation, the staff evaluates **several severe flooding scenarios**, which may include **PMF coincident with upstream dam failure and wind-induced waves**.
- **ANSI/ANS-2.8-1992** provides guidance for determination of appropriate combinations of flooding mechanisms along with their relative severity within the **combined events**.
- The staff uses the recommendations of ANSI/ANS-2.8-1992, supplemented with best current practices, to review the applicant's submittal in order to **ensure that the most severe flood at the plant site has been determined**.

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Review Methodology (cont.)

SRP 2.4.3 Review Procedures guidance:

- In its review of site flooding, **the staff may verify the applicant's estimate or perform its own independent analysis** using currently accepted runoff generation and flood routing techniques.
- **The staff should use currently accepted runoff generation and flood routing methods**, such as those made available by the US Army Corps of Engineers.

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Hierarchical Assessment Approach

Before initiating the assessment:

- Clearly identify the hazard
  - e.g., flooding from PMF…
- Clearly identify the Safety-Related SSCs to be protected
  - e.g., …at safety-related SSCs located at site grade
- Clearly identify the <u>applicant's evaluation finding</u> that staff must <u>independently check</u>
  - e.g., …by demonstrating that the maximum PMF water surface elevation is below the site grade.

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Hierarchical Assessment Approach

- Step-wise approach to estimating a hazard assessment at a site
  - The overarching goal is to provide reasonable assurance of adequate protection from the hazard, with sufficient safety margin given the limitations in knowledge, data, etc. (see GCD 2).
  - For the PMF example, we simulate a theoretical storm…

    PMF definition (ANSI/ANS 2.8): "The **hypothetical flood** that is considered to be the **most severe reasonably possible**, based on comprehensive hydrometeorological application of **probable maximum precipitation** and other hydrologic factors for **maximum flood runoff** such as sequential storms."

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Hierarchical Assessment Approach

- North Anna ESP SER (NUREG-1835)
  - Computed PMP following HMRs 51 & 52.
  - Continuously applied the maximum rainfall (PMP) rate (18 inches/6-hrs) over the entire watershed.
  - Assumed no precipitation losses occurred in order to maximize the flood generated by the PMP.
  - Result: Water Elevation < site grade…however when combined effects (i.e., surge and wave run-up) were included the water surface elevation > site grade.
    - So, we went to the next step in the hierarchy…

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Hierarchical Assessment Approach

- Next step in the Hierarchical Approach…reassess the conservatisms:
  - Same PMP following HMRs 51 & 52, but now distributed over time.
  - Staff simulated the runoff using the USACE model HEC-1 (predecessor to HEC-HMS).
  - Staff assumed no precipitation losses.
  - Staff peaked the Unit Hydrograph by 20%.
  - Following ANSI/ANS 2.8, the combined effects of surge and wave run-up were added to the peak water surface elevation.
  - The maximum flood elevation was 1.5 ft below site grade.
- Conclusion: Based on the conservatively estimated WSE, the site is considered dry. Staff therefore concluded that the applicant had met the requirements relating to PMFs on streams.

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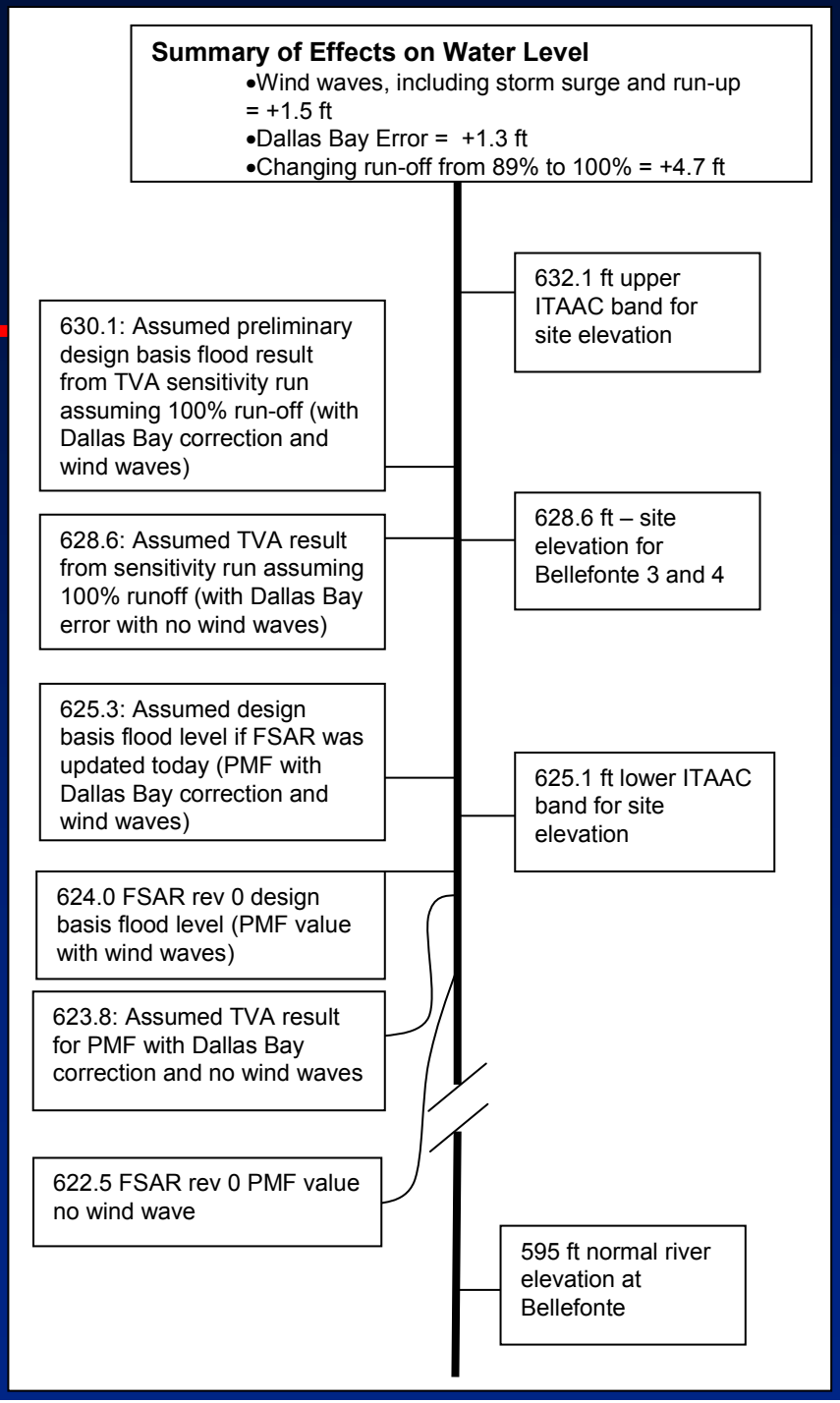
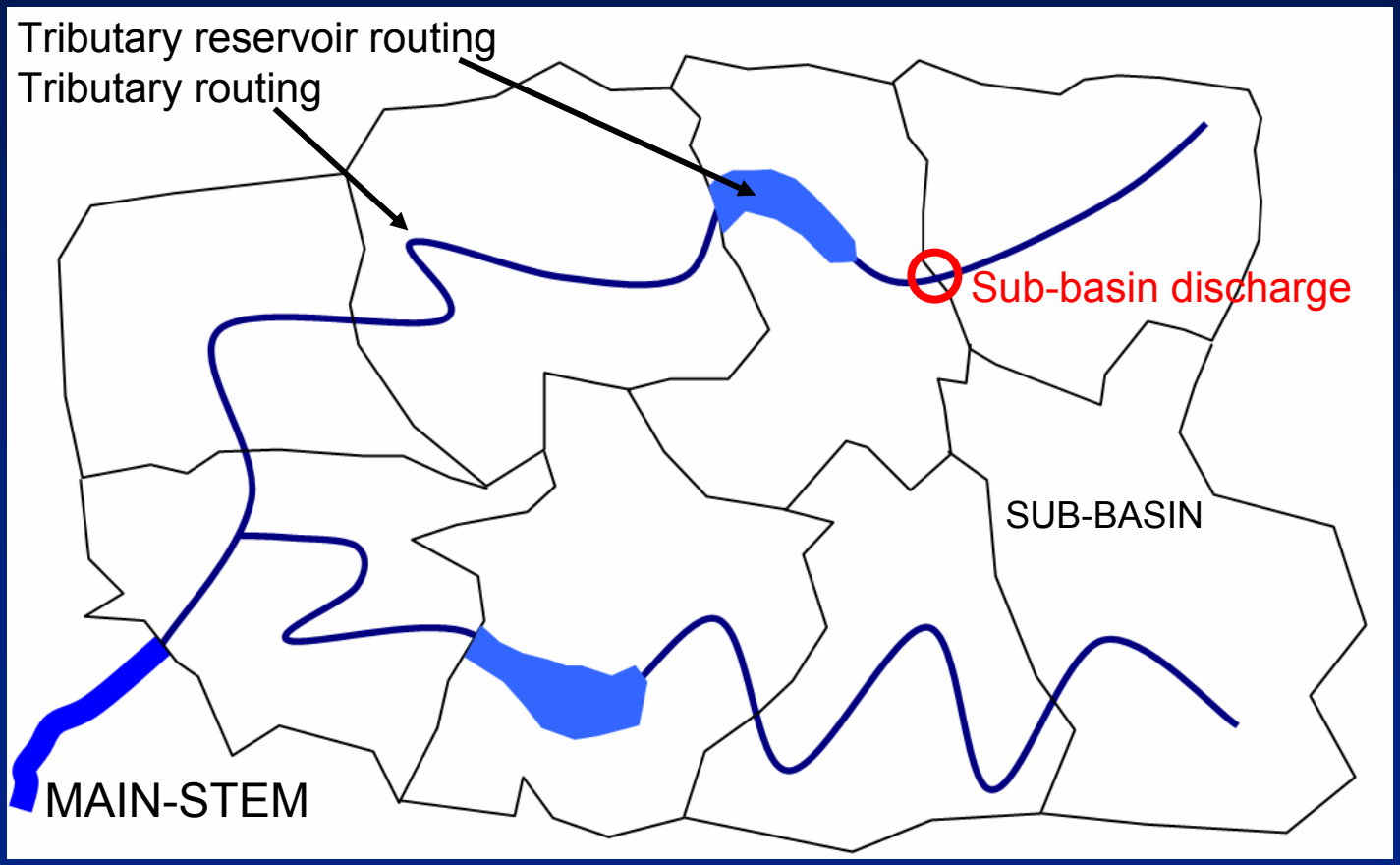
Bellefonte Review:

- Margin between design basis flood and site grade is small.
- Following process, NRC will review using a hierarchical approach. We will start with a bounding-type of analysis and then reassess the conservatisms as necessary. Hierarchical assessment examples:
  - Assume 100% runoff
  - Peak the unit hydrographs
  - Instantaneous upstream routing
  - Simplify dam breach scenarios



Generic Components of a Detailed Modeling Study (complex end of hierarchical review)



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Components of TVA's Modeling Study

- TVA's calculation package is very complex:
  - 46 sub-basin watersheds that cover 24,450 mi^2
    - 1 basin @ North Anna = 323 mi^2; 1 basin @ Clinton = 289 mi^2
    - Each basin has a unique hydrograph
  - 21 significant dams
    - Unique rating curves for each dam
  - Tributary routing
    - Lag-routing (w/ associated unique coefficients) for each stream
    - Level-pool routing with each reservoir
  - Modeling is done using numerous codes
    - 16 code V&V documents to be issued per July 10, 2008 TVA Letter
    - Input to SOCH involves 8 input codes
      - » UNITGRPH, THIESSEN, FLDHYDRO, TRIBROUTE, CHANROUT, DBREACH, CONVEYANCE WEIGHTD WIDTH
  - 11 'data packages' of bathymetry data to review

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NRC Review Methodology

- The process for reviewing FSAR sections 2.4.2-2.4.4 will involve:
  - Request TVA provide the input and output files for the design basis flood calculations.
  - Request TVA provide input and output files to document NRC-requested sensitivity runs (e.g., for example: (a) 20% peaking of the unit hydrographs, and (b) increasing the infiltration rate from 89 to 100%).
  - Following the SRP, staff will develop tools to independently verify TVA's output results. This may involve use of US Army Corps of Engineers (USACE) models. USACE models will be used by staff to assess TVA's results. USACE models will also allow staff to probe the SOCH models' parameters more efficiently, and to then ask RAIs about the SOCH parameters that TVA chose.
- Resolution of the QA issue is proceeding separately. This process may impact the SER schedule.

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Datasets NRC may Request

- Data will be requested via the e-RAI system.
- Historically, staff has requested data only AFTER the NRC staff has reviewed the data packages. This typically eases the regulatory burden (not a blanket RAI).
- Data staff expect to request include:
  - Input and output files, as mentioned earlier (Excel macros).
  - Unit hydrographs developed by TVA for each sub-basin.
  - USACE HEC-HMS input files being developed by TVA/Bechtel to verify each of the 46 sub-basins (part of the QA review).
  - USACE HEC-RAS/HEC-2 input files developed by TVA to verify SOCH (White Paper Section 4.2.5).
  - Tributary rivers: time-lag values developed by TVA.
  - Tributary reservoirs: stage-storage curves developed by TVA.
  - Rule curves for each dam (e.g., White Paper Figures 55-57).
  - Simulated outflow from each SOCH-simulated dam.
  - Cross-sectional data used to create the SOCH geometry files.

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Timeline for NRC Review

NRC is relying on TVA's schedule letters

June 30

Targeted Quantity of Verified Packages / Documents by Milestone Date				
Milestone Date	46 Unit Hydrographs Verified	11 Geometry Packages Verified	21 Dam Rating Curves Verified	16 Code V&V Documents Issued
07/31/2008	0	0	0	1
08/29/2008	1	3	6	2
09/30/2008	9	3	6	2
10/31/2008	14	3	6	4
11/28/2008	13	2	3	4
12/31/2008	9	0	0	3

July 10

Activity	Milestone Date
Issue Interim Milestone Schedule	7/11/08
Whitepaper revision	07/25/08
All Users Manuals Complete	08/22/08
All Excel codes - issue document	08/29/08
All Dam rating curves verified	10/03/08
All Geometry Input Data Packages verified	10/31/08
All Changes to Inputs Identified – Start final SOCH runs	11/14/08
All Unit Hydrograph input packages verified	12/19/08
New Controlling PMF Level Established / Draft FSAR Markup for review - High Confidence / Low risk of subsequent changes	12/31/08
All Input Data File Packages signed/available for review	01/05/09
All Software V&V Documents Issued	02/27/09
Phase 1 Documentation (Controlling) Complete	03/16/09
Phase 2 Documentation (Non-Controlling) Complete	04/28/09

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Timeline for NRC Review: TVA's Whitepaper Commitments

No.	Commitment	Source	Due Date	Status
c.1	Further comparative analyses between the two versions of the codes [SOCH88 vs. SOCH90PC] will be completed during the update and verification process.	Whitepaper R0 Page 34	End of Phase 1 03/16/09	
c.2	Issue Revision 1 of the Whitepaper	April 17th Letter	July 25th	Plan to update by July 25th, and incorporate any comments from the workshop.
c.3	As part of the update and verification process Chickamauga discharges with and without dam failure (those that would overtop the dam) will be computed past BLN site.	Whitepaper R0 Page 52	End of Phase 1 03/16/09	
c.4	During the update and verification process all flood routings will be computed down to Guntersville Dam which will allow determination of flood levels at BLN.	Whitepaper R0 Page 60	End of Phase 1 03/16/09	
c.5	River cross-sectional geometry data used in the SOCH code are being checked for accuracy and being updated where appropriate by current bathymetry data.	Whitepaper R0 Page 62	End of Phase 1 03/16/09	
c.6	The SOCH code will be recalibrated and verified to updated steady-state step backwater profiles for the affected reservoirs. This will include calibration of the 2003 flood against observed data in Watts Bar, Chickamauga, Nickajack, and Guntersville Reservoirs.	Whitepaper R0 Page 62	End of Phase 1 03/16/09	

No.	Commitment	Source	Due Date	Status
c.7	Unit hydrographs developed by TVA for the 45 sub-basins above BLN are being independently verified by using more recent storm data, where appropriate, and by use of the HEC1 computer code. Where the unit hydrographs differ, the basis for change will be documented. The updated unit hydrographs will be used to generate new design storm inflows, which will be verified by use of the HEC1 code.	Whitepaper R0 Page 62	End of Phase 1 03/16/09	
c.8	The updated runoff and stream course models will be used to compute PMF and seismic event maximum flood levels at BLN.	Whitepaper R0 Page 62	End of Phase 1 03/16/09	
c.9	Reservoir operating guides and spillway rating curves are being reviewed, checked and updated as appropriate.	Whitepaper R0 Page 62	End of Phase 1 03/16/09	

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NRC Review schedule

- NRC's review schedule is based on TVA's June 30 and July 10, 2008 schedule letters.
- As described in NRC's July 17 letter to TVA:
  - In December 2008, NRC will decide the subsequent length of the Phase 1 hydrology review.
  - Conditions for Review Ending Mid-August 2009
    - Access to all data sets per TVA's 6/30 & 7/10/08 schedules.
    - Nominal review period applied. NRC at risk since model not V&V'ed.
  - Conditions for Review Ending December 2009
    - Access to all verified and validated data in early May 2009.